

Claims

[Claim 1]

A multinuclear rare earth complex characterized in that a plurality of rare earth ions are coordinated
 5 with one or more types of molecules having a photosensitizing function.

[Claim 2]

The multinuclear rare earth complex according to claim 1, wherein the molecules having a
 10 photosensitizing function further have a vibrational energy quenching-suppressing function.

[Claim 3]

The multinuclear rare earth complex according to claim 1, which is represented by the general formula:

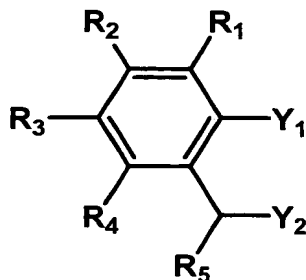
15 $L_p L'_q (Ln)_r X_s,$

wherein

L is a ligand having a photosensitizing function represented by the general formula:

[Chemical Formula 1]

20



wherein R₁, R₂, R₃, R₄ and R₅ are independently
 hydrogen, a hydroxy group, a substituted or unsubstituted
 25 amino group, a substituted or unsubstituted aryl group, a nitro group, a cyano group, an alkyl group or a cycloalkyl

group represented by -R, an alkoxy group represented by -OR, or an acyl group represented by -C(C=O)R, where R is a substituted or unsubstituted alkyl group or cycloalkyl group having a carbon number of 1 to 20;

5 Y₁ is -OH; and

 Y₂ is =O;

p is an integer of 1 to 40;

L' is a ligand which is a hydroxide ion;

q is an integer of 0 to 8;

10 Ln is a rare earth ion;

r is an integer of 2 to 20, and a plurality of Ln may be the same or different from each other;

X is O, -OH, S, -SH, Se or Te;

s is an integer of 1 to 20, and a plurality of X may be the same or different from each other when s is an integer of 2 to 20; and further, the integers p, r and s have a relationship indicated by the expression:

[Expression 1]

20 $1 \leq p/r \leq 4, 1 \leq r/s \leq 4$

wherein a manner how Ln is coordinated with L:

Coordination Manner (A) where both Y₁ and Y₂ bind to the identical Ln; Coordination Manner (B) where Y₁ and Y₂ bind to different Ln, respectively; and a combination thereof, wherein when Ln is coordinated with Y₁, a proton leaves from -OH represented by Y₁ to form -O-, thereby Ln is coordinated with L via -O-.

[Claim 4]

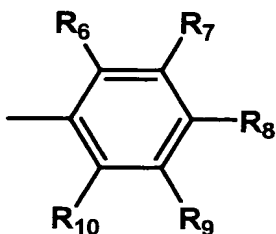
30 The multinuclear rare earth complex according

to claim 3, wherein at least one of substituents R₁, R₂, R₃, R₄ and R₅ is an alkyl group or a cycloalkyl group represented by -R, an alkoxy group represented by -OR or an acyl group represented by -C(=O)R, where R is a substituted or unsubstituted alkyl group or cycloalkyl group having a carbon number of 1 to 20.

[Claim 5]

The multinuclear rare earth complex according to claim 4, wherein R₅ is represented by the formula:

[Chemical Formula 2]



wherein R₆, R₇, R₈, R₉ and R₁₀ are independently hydrogen, a hydroxy group, a substituted or unsubstituted amino group, a substituted or unsubstituted aryl group, a nitro group, a cyano group, an alkyl group or a cycloalkyl group represented by -R, an alkoxy group represented by -OR, or an acyl group represented by -C(C=O)R, where R is a substituted or unsubstituted alkyl group or cycloalkyl group having a carbon number of 1 to 20, where at least one of R₁, R₂, R₃, R₄, R₆, R₇, R₈, R₉ and R₁₀ is an alkyl group or a cycloalkyl group represented by -R, an alkoxy group represented by -OR, or an acyl group represented by -C(C=O)R, where R is a substituted or unsubstituted alkyl group or cycloalkyl group having a carbon number of 1 to 20.

[Claim 6]

The multinuclear rare earth complex according to claim 4, wherein R_5 is an alkyl group or a cycloalkyl group represented by $-R$, an alkoxy group represented by $-OR$, or an acyl group represented by $-C(C=O)R$, where R is a substituted or unsubstituted alkyl group or cycloalkyl group having a carbon number of 1 to 20.

[Claim 7]

The multinuclear rare earth complex according to claim 5 or 6, wherein R is a substituted or unsubstituted alkyl group having a carbon number of 6 to 12.

[Claim 8]

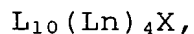
The multinuclear rare earth complex according to claim 7, wherein R is a substituted or unsubstituted alkyl group having a carbon number of 8 to 12.

[Claim 9]

The multinuclear rare earth complex according to claim 1, wherein the rare earth ion is an ion of lanthanide selected from a group consisting of europium (Eu), terbium (Tb), neodymium (Nd), samarium (Sm), erbium (Er) and ytterbium (Yb) or a combination thereof.

[Claim 10]

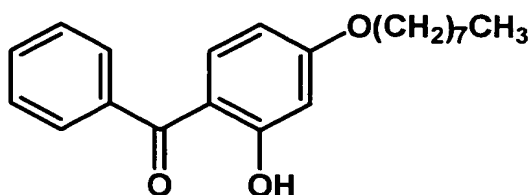
The multinuclear rare earth complex according to claim 5, which is represented by the general formula:



wherein

L is a ligand represented by the formula:

[Chemical Formula 3]



Ln is a europium (Eu) ion; and

X is O, and which has the following properties:

Elementary Analysis: as $C_{210}H_{250}O_{31}Eu_4$,

5 Theoretical values C, 65.04%; H, 6.50%; Eu, 15.67%

Observed values C, 64.90%; H, 6.39%; Eu, 15.41%

IR (KBr, cm^{-1}): (ν_{CH})2922, ($\nu_{C=C}$)1596, (ν_{Ph-O})1243

1H -NMR($CDCl_3$): δ 12.7(1H,s), δ 7.6-7.2(3H,m), δ 6.5-6.4(5H,d),
 δ 4.0(2H,t), δ 1.8(2H,m), δ 0.9(3H,t)

10 FAB-MS: m/z 3552.1 [$Eu_4(L^-)_9O^{2-}$] $^+$.

[Claim 11]

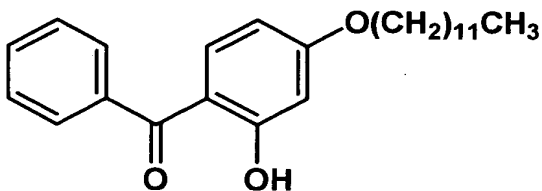
The multinuclear rare earth complex according to claim 5, which is represented by the general formula:

$L_{10}(Ln)_4X$,

15 wherein

L is a ligand represented by the formula:

[Chemical Formula 4]



Ln is a europium (Eu) ion; and

20 X is O, and which has the following properties:

Elementary Analysis: as $C_{250}H_{330}O_{31}Eu_4$,

Theoretical values C, 67.64%; H, 7.49%; Eu, 13.69%

Observed values C, 67.50%; H, 7.45%; Eu, 13.49%

IR (KBr, cm^{-1}): (ν_{CH}) 2924, ($\nu_{\text{C}=\text{C}}$) 1608, ($\nu_{\text{Ph-O}}$) 1247

$^1\text{H-NMR}$ (CDCl_3): δ 12.7 (1H, s), δ 7.6-7.3 (3H, m), δ 6.5-6.4 (5H, d),
 δ 4.0 (2H, t), δ 1.8 (2H, m), δ 0.9 (3H, t)

5 FAB-MS: m/z 4055.9 $[\text{Eu}_4(\text{L}^-)_9\text{O}^{2-}]^+$.

[Claim 12]

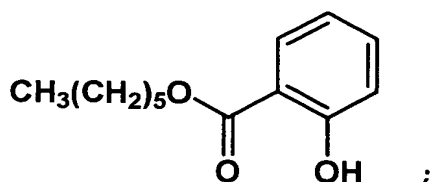
The multinuclear rare earth complex according to claim 6, which is represented by the general formula:

$\text{L}_{16} \text{L}'_8 (\text{Ln})_9 \text{X}_2$,

10 wherein

L is a ligand represented by the formula:

[Chemical Formula 5]



L' is OH^- ;

15 Ln is a terbium (Tb) ion; and

X is O, and which has the following properties:

Elementary Analysis: as $\text{C}_{214}\text{H}_{324}\text{O}_{72}\text{NTb}_9$,

Theoretical values C, 46.79%; H, 5.93%; Tb, 26.46%

Observed values C, 46.72%; H, 5.18%; Tb, 26.04%

20 IR (KBr, cm^{-1}): (ν_{CH}) 2957, 2931, ($\nu_{\text{C}=\text{O}}$) 1674, 1637,
 ($\nu_{\text{C}=\text{C}}$) 1598, ($\nu_{\text{Ph-O}}$) 1243

$^1\text{H-NMR}$ (CDCl_3): δ 10.9 (1H), δ 7.9-6.9 (4H), δ 4.3 (2H),
 δ 1.8 (2H), δ 1.4 (6H), δ 0.9 (3H)

FAB-MS: m/z 5140.2 $[\text{Tb}_9(\text{L}^-)_{16}(\text{O}^{2-})_2(\text{OH}^-)_8+2\text{H}^+]^+$.

25 [Claim 13]

A fluorescent substance containing the multinuclear rare earth complex according to any one of

claims 1 to 12.

[Claim 14]

A formed resin materials characterized in that
the fluorescent substance according to claim 13 is
5 compounded in a plastic polymer.